GROUNDWATER EVALUATION OF GEOLOGIC HAZARDS AT THE HAGERMAN FOSSIL BEDS TWIN FALLS COUNTY, IDAHO

By

Paul Summers
Senior Hydrogeologist

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
SERVICE CENTER
DENVER FEDERAL CENTER, BUILDING 50
P.O. BOX 25047
LAKEWOOD, COLORADO 80225-0047

December 1985

GROUNDWATER EVALUATION OF GEOLOGIC HAZARDS AT THE HAGERMAN FOSSIL BEDS TWIN FALLS COUNTY, IDAHO

By

Paul Summers
Senior Hydrogeologist

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
SERVICE CENTER
DENVER FEDERAL CENTER, BUILDING 50
P.O. BOX 25047
LAKEWOOD, COLORADO 80225-0047

December 1985

GROUND-WATER EVALUATION OF THE HAGERMAN GEOLOGIC HAZARD AREA

Introduction

This report is the result of field investigations of massive slumping and related slope failures near Hagerman, Idaho. The specific area of concern is along the west bank of the Snake River, about 1-1/2 miles due west of the town of Hagerman, in the west half of T. 7 S., R. 13 E., (about 30 miles northwest of the town of Twin Falls).

The rate and extent of slope failure in the Hagerman area has increased substantially during the past 12 months. An investigation was initiated by the Boise District, Bureau of Land Management, to study the occurrence and flow of ground water in the area, to pinpoint the cause of the slope failure, and to make recommendations on methods of preventing further damage to fossil beds in this area.

Geology

The strata in the study area are comprised of thick lake and stream deposits of the Glenns Ferry Formation (the Hagerman Lake Beds of Stearns, 1938). The lake beds are about 2000 ft. thick, and include discontinuous volcanic flows locally as much as 100 ft. thick. Inspection of outcrops of lake beds in the area where slumping has occurred shows that thick layers of friable sand and silt predominate the lithology. Cross-bedding of the sand deposits was observed in this area, indicating the water-lain origin of the deposits.

GROUND-WATER EVALUATION OF THE HAGERMAN GEOLOGIC HAZARD AREA

Introduction

This report is the result of field investigations of massive slumping and related slope failures near Hagerman, Idaho. The specific area of concern is along the west bank of the Snake River, about 1-1/2 miles due west of the town of Hagerman, in the east half of T. 7 S., R. 13 E., (about 30 miles northwest of the town of Twin Falls).

The rate and extent of slope failure in the Hagerman area has increased substantially during the past 12 months. An investigation was initiated by the Boise District, Bureau of Land Management, to study the occurrence and flow of ground water in the area, to pinpoint the cause of the slope failure, and to make recommendations on methods of preventing further damage in fossil beds in this area.

Geology

The strata in the study area are comprised of thick lake and stream deposits of the Glenns Ferry Formation (the Hagerman Lake Beds of Stearns, 1936). The lake beds are about 2000 ft. thick, and include discontinuous volcanic flows locally as much as 100 ft. thick. Inspection of outcrops of lake beds in the area where slumping has occurred shows that thick layers of friable sand and silt predominate the lithology. Cross-bedding of the sand deposits was observed in this area, indicating the water-lain origin of the deposits.

Malde and Powers (1972) describe the Glenns Ferry formation as being characterized by abrupt changes in facies between neighboring sequences which include (1) silt in massive layers with faint banding, (2) sand in evenly layered thick beds cemented locally to form flaggy sandstone, (3) thinly bedded shale, (4) ripple-marked sand and silt, (5) granitic sand and fine pebble gravel, and (6) quartzitic cobble gravel.

Stearns et al. (1938) describes the lake beds as being partly consolidated clay, silt, and cross-bedded sandstone; locally the sand is cemented by calcareous or limonitic cement. Conglomerate lenses occur which contain water-worn gravel derived from volcanic rocks exposed to the south.

The upper portion of the slopes in the study area appears to be comprised primarily of the sand and silt facies, with some local occurrences of pebble gravel as discontinuous lenses within the sand facies.

The lake beds are very extensive; geologic mapping by Malde and Powers (1972) indicate that these beds extend at least 30 miles west of this study area, and 8-10 miles to the south. The beds are nearly horizontal, dipping only about 3 degrees except where slope failure has occurred (Stearns et al., 1938; Malde and Powers, 1972).

Only one fault occurs in or near the study area. This is a northwest-trending fault that occurs within the Glenns Ferry Formation, and mapped (Malde and Powers, 1972) into the SW1/4 of sec. 32, T. 7 S., R. 13 E. The extent of this fault is not known, because the gravel cap on top of the Glenns Ferry

Naide and Powers (1972) describe the Ringold Formation as being characterized by abrupt changes in facies between interfingering sequences which include (1) silt in massive layers with solid bedding, (2) sand in evenly layered cross beds cemented locally to form ledges sandstone, (3) thinly bedded clays, (4) ripple-marked sand and silt, (5) granitic sand and fine pebble gravel, and (6) quartzitic coarse gravel.

Stearns et al. (1938) describe the lake beds as being poorly consolidated clay, silt, and cross-bedded arkosic sand. Locally the sand is cemented by calcareous and limonitic cement. Conglomerate lenses occur which contain water-worn gravel derived from volcanic rocks exposed to the north.

The upper portion of the Ringold in the study area appears to be comprised primarily of the sand and silt facies, with some local occurrences of pebble gravel as discontinuous lenses within the sand facies.

The lake beds are very extensive; geologic mapping by Naide and Powers (1972) indicate that these beds extend at least 30 miles west of this study area, and 5-10 miles to the north. The beds are nearly horizontal, dipping only about 1 degree except where slope failure has occurred (Stearns et al., 1938; Naide and Powers, 1972).

Only one fault occurs in or near the slide area. This is a northwest-trending fault that occurs within the Saddle Mountains Basalt and mapped (Naide and Powers, 1972) into the SW1/4 of sec. 21, T. 7 N., R. 31 E. The extent of this fault is not known, because the gravel cap on top of the Ringold Formation

Formation covers the fault in sec. 32. If the fault does extend beyond Sec. 32, it could influence ground-water flow of the regional aquifer into the study area, as the fault is likely a barrier to ground-water movement. Ground-water flow into this area is from the north, as indicated by water level contours on the regional aquifer (Moffat and Jones, 1984).

Ground Water

A detailed ground-water study in 1982 of the Bruneau Plateau (Moffat and Jones, 1984) included the measuring of several wells near the study area. Water levels in wells across the Bruneau Plateau indicate three aquifer systems: (1) a perched aquifer, (2) the regional aquifer, and (3) a deep thermal-water aquifer (Moffat and Jones, 1984, p. 18). Although the extent of the perched aquifer in the Hagerman area was not precisely defined in the 1982 study, recent seepage in the Snake River Cliffs shows that one does exist.

Stearns et al. (1938) suggests that the permeability of the lake beds is very low due to the fine-grained character of the sediments. However, permeability in lake sediments can be extemely variable. Zones of very high permeability are often layered with zones of low permeability. In addition, thin clay beds within the sandy layers may retard flow somewhat, and divert flow laterally. Observable ground water seepage in the Hagerman study area is due to ground water flowing laterally along a thick clay bed or along the contact of sediments with basalt flows that occur within the lake sediments. Ground water flow was observed by BLM personnel at the basalt outcrop in the north end of the study area (McClendon, 1985).

The regional aquifer system is about 500-700 ft. below the land surface in the study area. Measurable ground-water seepage is occurring at several locations along the canyon wall in a zone generally 100-300 ft. below land surface, indicating that seepage is originating from a perched aquifer above the regional flow system. The regional system thus is not contributing to ground-water seepage in the Hagerman fossil locality. A perched aquifer within lake sediments is a common situation, and fits into the hydrogeologic setting in this area. The Stearns investigation indicated that the lake beds in the Bruneau Plateau are locally saturated by irrigation water (Stearns et al., 1938, p.55).

Water level contours from well data in the regional aquifer system show ground-water flow to be generally towards the north (Moffat and Jones, 1984). However, the deeply incised Snake River Canyon influences ground-water flow in the vicinity of the fossil beds, diverting ground-water flow eastward. Flow in the perched aquifer is also to the east, influenced by the deeply incised river valley, and to a lesser extent by the dip of the sediments.

Ground-water levels in the Bruneau Plateau rise and fall coincident with the irrigation season. Moffat and Jones (1984) plotted hydrographs of wells in the Bruneau Plateau and conclude that:

> ". . . water levels begin to rise when water is released into canals and fields; reach a plateau of high levels through the summer irrigation season; begin to decline at the beginning of the growing season; and continue to an annual low just prior to the start of the next irrigation season." (Moffat and Jones, 1984, p. 22)

The regional aquifer system is about 500-700 ft. below the land surface in the study area. Measurable ground-water seepage is occurring at several locations along the canyon wall in a zone generally 100-300 ft. below land surface, indicating that seepage is originating from a perched aquifer above the regional flow system. The regional system thus is not contributing to ground-water seepage in the Hagerman fossil locality. A perched aquifer within lake sediments is a common situation, and fits into the hydrogeologic setting in this area. The Stearns investigation indicated that the lake beds in the Bruneau Plateau are locally saturated by irrigation water (Stearns, et al., 1938, p.55).

Water level contours from well data in the regional aquifer system show ground-water flow to be generally towards the north (Moffat and Jones, 1984). However, the deeply incised Snake River Canyon influences ground-water flow in the vicinity of the fossil beds, diverting ground-water flow eastward. Flow in the perched aquifer is also to the east, influenced by the deeply incised river valley, and to a lesser extent by the dip of the sediments.

Ground-water levels in the Bruneau Plateau rise and fall coincident with the irrigation season. Moffat and Jones (1984) plotted hydrographs of wells in the Bruneau Plateau and conclude that:

> ". . . water levels begin to rise when water is released into canals and fields, reach a maximum or high levels through the summer irrigation season; begin to decline at the beginning of the growing season; and continue to an annual low just prior to the start of the next irrigation season." (Moffat and Jones, 1984, p. 22)

Although hydrographs of wells in the Hagerman study area were not prepared in the Moffat study, a similar pattern would likely be displayed.

The mean annual precipitation during the years 1961-1980 for this area ranges from 8.0 to 10.9 inches. Monthly precipitation averaged .5 in. to 1.0 in. each month except in July, when the average was less than .5 in. at three of four stations (Moffat and Jones, 1984, p. 11).

<u>Relationship of Slope Failure to Ground-Water Occurrence</u>

An evaluation of slope failure must include an assessment of the ground-water flow system as a possible primary causal factor. In the Hagerman area, ground-water seepage was observed in three types of situations: (1) along the walls of escarpments formed by recent slumping of lake sediments, (2) at several locations along the canyon walls but not related to slumping, and (3) at the contact of the lake sediments with a basalt flow. The distribution of seepage as mapped by BLM personnel (McClendon, 1984, personal communication) shows that ground water is seeping out generally in a narrow zone of elevation, and in a pattern related to the location of irrigation canals.

The source of ground water that saturates the lake deposits is most likely leakage from unlined canals in the vicinity. This is substantiated in a recent study of ground water in this area, indicating that the major source of recharge to the perched aquifer system is leakage from unlined irrigation canals (Moffat and Jones, 1984, p. 22). In the study area, extremely large

Although hydrographs of wells in the Hagerman study area were not prepared in the Moffat study, a similar pattern would likely be displayed.

The mean annual precipitation during the years 1961-1980 for this area ranges from 8.6 to 10.5 inches. Monthly precipitation averaged .5 in. to 1.0 in. each month except in July, when the average was less than .5 in. at three of four stations (Moffat and Jones, 1984, p. 11).

<u>Relationship of Slope Failure to Ground-water Occurrence</u>

An evaluation of slope failure must include an assessment of the ground-water flow system as a possibly primary causal factor. In the Hagerman area, ground-water seepage was observed in three types of situations: (1) along the walls of escarpments formed by recent slumping of lake sediments, (2) at several locations along the canyon walls that are not related to slumping, and (3) at the contact of the lake sediments with a basalt flow. The distribution of seepage as mapped by BLM personnel (Hutchinson, 1984, personal communication) shows that ground water is seeping out generally in a narrow zone of elevations, and in a pattern related to the location of irrigation canals.

The source of ground water that saturates the lake deposits is most likely leakage from unlined canals in the vicinity. This is substantiated in a recent study of ground water in this area, indicating that the major source of recharge to the perched aquifer system is leakage from unlined irrigation canals (Moffat and Jones, 1984, p. 52). In the study area, extremely large

volumes of water are being pumped up onto the plateau from the Snake River and discharged into canals which are in close proximity to the area where slope failure is occurring. Field evidence suggests that canal water is percolating downward until it encounters an impermeable layer, thence moves laterally eastward toward the escarpment. This process has likely been occurring for several years, and has probably only recently saturated the slope face sufficiently to cause instability in the lake sediments.

That the canals are the most probable source of the ground water is suggested by the localized occurrence of seepage in this area. If the seepage was due to ground-water recharge of the lake beds due to unusually high precipitation or widespread ground-water flow into the area from another source, we would expect to observe seepage almost everywhere along the exposed hillsides; especially south of the existing seepage zone. However, this is not the case.

Slope failure in the Hagerman area is caused by the combination of three factors: (1) sediments which are loosely cemented, (2) a source of ground-water recharge which has saturated the poorly consolidated lake sediments, and (3) steep canyon walls that induce localized slumping when the sediments become sufficently saturated. Slumping of the canyon walls does not occur unless the beds are heavily saturated from an external water source. Precipitation alone is not sufficient to saturate the lake beds to the point of being unstable.

Summary and Recommendations

Substantial ground-water seepage is occurring in the lake beds exposed in

hillsides west of Hagerman. Geologic and hydrologic evidence observed during the field investigation indicates that the seepage is due to leakage of water downward through unlined irrigation canals. This ground-water recharge is to the shallow aquifer (perched) that occurs several hundred ft. above the regional aquifer system.

Some additional water is likely being contributed to the perched aquifer by sprinkler irrigation, which is conducted during the summer across the top of the plateau. In addition, irrigation practices are contributing excess water to surface runoff near the cliffs and is causing localized accelerated gully erosion in the canyon walls.

The general rate of ground-water flow within the lake sediments should be very slow due to the fine-grained character of the sediments. This may account for the long time period required for seepage in the canyon walls to become significant. Water is likely moving rapidly in some layers and very slowly in others, depending on the degree of sorting and the size of the grains within the sediments.

Although the regional aquifer system in the vicinity of the study area is well documented, little is known about the perched aquifer. A few strategically located test holes into the perched aquifer would help define the flow system, provide details about the stratigraphy within the lake beds (facies changes need to be identified), and define the extent and magnitude of leakage from the canals.

hillsides west of Sagebrush. Geologic and hydrologic evidence observed during the field investigation indicates that the seepage is due to leakage of water conveyed through unlined irrigation canals. This ground-water recharge is to the shallow aquifer (perched) that occurs several hundred ft. above the regional aquifer system.

Some additional water is likely being contributed to the perched aquifer by sprinkler irrigation, which is conducted during the summer across the top of the plateau. In addition, irrigation practices are contributing excess water to surface runoff near the cliffs and in certain localities accelerated gully erosion of the canyon walls.

The general rate of groundwater flow within the lake sediments should be very slow due to the fine-grained character of the sediments. This may account for the long time period required for seepage in the canyon walls to become significant. Water is likely moving rapidly in some layers and very slowly in others, depending on the degree of sorting and the size of the grains within the sediments.

Although the regional aquifer system in the vicinity of the study area is well documented, little is known about the perched aquifer. A few strategically located test holes into the perched aquifer would help define the flow system, provide details about the stratigraphy within the lake beds (facies changes need to be identified), and define the extent and magnitude of leakage from the canals.

If time and funds permit, it would probably be worthwhile to drill one hole sufficiently deep to intercept the underlying volcanic flow in the northern part of the study area. Ground water is likely occurring at this contact, and it would be of scientific interest to verify this situation. A deep test well is not critical to the evaluation of the canal seepage problem; however, it would provide additional information about the general ground water flow system and the geological conditions in the subsurface.

Placing test holes near the canals and measuring water levels to determine the ground water gradient will help define the extent of recharge from the canals into the lake sediments and provide information on direction of flow. A configuration of several holes (8-9) would be the minimum configuration needed to define canal leakage. Additional holes would help define the perched ground-water flow system and its relationship to the regional aquifer system, but would not be required to completely evaluate the ground water problem of canal leakage being addressed now.

References:

Malde, H. E., and Powers, H. A., 1972, Geological Map of the Glenns Ferry-Hagerman Area, West-Central Snake River Plain, Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-696, scale, 1:48,000.

McClendon, M., 1985, Personal communication, U.S. Bureau of Land Management.

Moffat, R. L., and Jones, M. L., 1984, Availability and Chemistry of Ground Water on the Bruneau Plateau and Adjacent Eastern Plain in Twin Falls County, south-central Idaho: U.S. Geological Survey Water-Resources Investigations Report, 84-4065. 43 p.

Young, M. W., 1984, Evaluation of Hydrologic Processes Affecting Soil Movement in the Hagerman Fauna Area, Hagerman, Idaho: U.S. Geological Survey Water-Resources Investigations Report, 84-4137. 17 p.

Stearns, H. T., Crandall, L., and W. G. Steward, 1938, Geology and Ground-Water Resources of the Snake River Plain in Southeastern Idaho: U.S. Geological Survey Water-Supply Paper 774. 266p., maps.